Updates on Ozone and Health

16 September 2020, virtual meeting
Multiple effects of exposure to ozone

- Burning eyes & throat; mucous irritation
- Shortness of breath, wheezing, coughing
- Pulmonary inflammation
- Asthma attacks, chest pain, increased risk of respiratory diseases
- Headache
- Increased risk of heart attacks
Ozone in WHO air quality guidelines (WHO AQGs)

Update of WHO Global Air Quality Guidelines

Ongoing update since 2016 ...
Acute and chronic effects of ozone

Acute responses

• pulmonary system effects
• cardiovascular system effects
• time series morbidity and mortality effects

Chronic effects

• reduced lung function
• development of asthma
• development of atherosclerosis
• reduction in life expectancy
Reinforced evidence on short-term exposure and all-cause, cardiovascular and respiratory mortality, respiratory and cardiovascular hospital admissions (adjusted for co-pollutants)

Evidence for effects of long-term exposure to ozone on respiratory and cardiorespiratory (less conclusive) mortality (based on large cohort studies)

In new follow-up long-term exposure studies evidence on asthma incidence and severity, hospital care for asthma, and lung function growth

New experimental evidence of chronic injury and long-term structural changes in the airways due to prolonged exposure to O$_3$, and to O$_3$ and allergens combined

New epidemiological and experimental data suggestive of an effect of O$_3$ on cognitive development and reproductive health, including preterm birth
Adverse health outcomes with known baseline rates, such as mortality and hospital admissions, most suited for health impact assessments (HIA)

For short-term exposure, HIA calculations feasible for all-age, all-cause, cardiovascular and respiratory mortality, and for the age group 65+, for respiratory and cardiovascular hospital admissions

HIA calculations for short-term exposures to assume linear CRF for the outcomes considered, with the recommended cut-off points

Due to uncertainties about the effects of long-term exposure, a sensitivity scenario recommended for HIA for respiratory and cardiopulmonary mortality
Expert consultation on the evidence for the update of the WHO Global AQG

General agreement with the REVIHAAP conclusions on a need to revisit the current guidelines for PM, $O_3$, NO$_2$, and SO$_2$.

The evidence base for the association between short- and long-term exposure to these pollutants and health effects has become much larger and broader since 2006.
Expert consultation – short-term effects of O$_3$

New mixed evidence of effects at levels below 100 $\mu$g/m$^3$ for an average 8-h mean exposure

Consideration of additional short-term averaging times

Consideration of multipollutant models

The use of the SOMO35 indicator in the context of management issues rather than in the development of the guidelines
Expert consultation – long-term effects of O₃

Consideration of the new evidence on health effects of long-term exposure in the revision of the guidelines

Consideration of US EPA ISA for O₃ and Related Photochemical Oxidants (2013):

- likely to be a causal relationship between long-term exposure and respiratory effects
- the evidence suggestive of a causal relationship for long-term exposure and cardiovascular effects, reproductive and developmental effects, cancer, and total mortality

Strong support to review the evidence to consider the development of AQG level for long-term exposure

- potential major policy implications, including the need to address global emissions of ozone precursors, and impacts on other areas, such as CC mitigation
- need to address confounding due to multipollutant exposure, consideration of seasonality, and effects due to repeated peaks of exposure versus chronic exposure
Update of the WHO Global AQGs: systematic reviews

- Long-term exposure to PM and all-cause and cause-specific mortality
- Short-term exposure to CO and ischaemic heart disease
- Long-term exposure to PM and all-cause and cause-specific mortality
Systematic reviews AQGs – short-term effects (I)

Health outcomes: all-cause mortality

67 eligible papers, most studies from Europe, North America and Asia

24-h average: pooled effect size 1.0043 (1.0034 - 1.0052) per 10µg/m³

CRF: some evidence of non-linearity in half of the papers

Multipollutant models: associations attenuated upon adjustment for co-pollutants, but analysed in few studies

Certainty in the evidence: judged as high for all-cause mortality
Health outcomes: emergency room visits / hospital admissions due to asthma

Eligible: 50 studies, mostly from Europe, North America and Asia

Max 8-h daily or average 24-h concentration: pooled effect size 1.008 (1.005–1.011) per 10 µg/m³

Max 1-h daily concentration: pooled effect size 1.017 (0.973–1.063) per 10µg/m³

CRF: some evidence of non-linearity (8-h or 24-h)

Certainty in the evidence:

- judged as high for O₃ (8-h or 24-h)
- not analysed for O₃ (1-h), because the associations were non-significant
Systematic reviews AQGs – long-term effects

Health outcomes: all-cause mortality, respiratory mortality, COPD mortality, ALRI mortality

Eligible: 20 articles, majority from North America and Europe

Annual metrics: associations with all-cause and respiratory mortality 0.97 (0.93, 1.02) and 0.99 (0.89, 1.11) per 10µg/m³, respectively

Peak metrics: associations with all-cause and respiratory mortality 1.01 (1.00, 1.02) and 1.02 (0.99, 1.05) per 10µg/m³, respectively

CRF: limited evidence to reject the assumption of linearity

Multipollutant models: associations attenuated upon adjustment for co-pollutants in some studies

Certainty in the evidence: judged as moderate for O₃ peak exposure and all-cause mortality, and low for other exposure-outcome pairs assessed
<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Effects on health</th>
<th>Assessment</th>
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<tbody>
<tr>
<td>Particulate Matter (&lt;2.5 μm)</td>
<td>Death</td>
<td>causal</td>
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<td></td>
<td>Cardiovascular diseases</td>
<td>causal</td>
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<td></td>
<td>Lung cancer</td>
<td>causal</td>
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<td></td>
<td>Respiratory diseases</td>
<td>probably causal</td>
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<tr>
<td>Ozone</td>
<td>Short-term effects on respiratory diseases</td>
<td>causal</td>
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<td></td>
<td>Short-term effects on cardiovascular diseases</td>
<td>probably causal</td>
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<td></td>
<td>Respiratory diseases</td>
<td>probably causal</td>
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<tr>
<td>Nitrogen dioxide</td>
<td>Short-term effects on respiratory diseases</td>
<td>causal</td>
</tr>
<tr>
<td></td>
<td>Respiratory diseases</td>
<td>probably causal</td>
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</tbody>
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US EPA ISA for O₃ and Related Photochemical Oxidants (2013)
Main conclusions presented at 23rd meeting of the TFH

For short-term exposure and respiratory effects the evidence continues to suggest a ‘causal’ relationship (as in 2013)

For short-term exposure and metabolic effects emerging evidence suggests a ‘likely to be causal’ relationship

For short-term exposure and cardiovascular effects and mortality, revision of causality assessment from ‘likely to be causal’ to ‘suggestive of, but not sufficient to infer, a causal relationship’

For long-term exposure, metabolic and reproductive effects, the evidence ‘suggestive of, but not sufficient to infer, a causal relationship’

Continued support to a linear CRF, with less certainty at lower concentrations below 30–40 ppb
### Causality Determinations for Health Effects of Ozone

<table>
<thead>
<tr>
<th>Health Outcome</th>
<th>Short-term Exposure</th>
<th>Long-term Exposure</th>
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<tbody>
<tr>
<td>Respiratory</td>
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<tr>
<td>Metabolic</td>
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<td>Cardiovascular</td>
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<td>Nervous System</td>
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<td>Reproductive</td>
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<td>Male/Female Reproduction and Fertility</td>
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<td>Pregnancy and Birth Outcomes</td>
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<tr>
<td>Cancer</td>
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<td>Mortality</td>
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**Causal** | **Likely causal** | **Suggestive** | **Inadequate** |

* new causality determination; ↓ causality determination changed from likely causal to suggestive; * change in scope of health outcome category from 2013 Ozone ISA

Final comments

- The relationship between short-term exposure to ozone and increased respiratory-related mortality and increases in respiratory-related emergency room visits and hospital admissions considered causal.

- The relationship between short-term ozone exposure and the increase in cardiovascular mortality with less evidence on causality of the association.

- Long-term exposure to ozone correlated with increased all-cause and respiratory-related mortality, with less evidence on causality of the association; moderate certainty in the evidence for peak exposure and all cause mortality.

- The evidence on the association between short- and long-term exposure to ozone and health effects has been growing, but methodological challenges remain due to complex relationships between ozone and other pollutants.
Thank you